

09261 Abstracts Collection
Models and Algorithms for Optimization in
Logistics
— **Dagstuhl Seminar** —

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**09261 Executive Summary – Models and Algorithms for
Optimization in Logistics**

From June 21 to June 26, 2009, the Dagstuhl Seminar 09261 on Models and Algorithms for Optimization in Logistics was held in the International Conference and Research Center (IBFI), Schloss Dagstuhl. During the seminar, several participants presented their current research, and ongoing work and open problems were discussed. Abstracts of the presentations given during the seminar as well as abstracts of seminar results and ideas are put together in this paper.

The first section describes the seminar topics and goals in general. Links to extended abstracts or full papers are provided, if available.

Keywords: Logistics, optimization, transport

Joint work of: Barnhart, Cynthia; Clausen, Uwe; Lauther, Ulrich; Möhring, Rolf

Extended Abstract: <http://drops.dagstuhl.de/opus/volltexte/2009/2175>

**Optimization Approaches to Airline Industry Challenges:
Airline Schedule Planning and Recovery**

Cynthia Barnhart (MIT - Cambridge, US)

The airline industry has a long history of developing and applying optimization approaches to their myriad of scheduling problems.

These problems have several challenging characteristics, the two most challenging of which include: 1) they span long- and short-term horizons, from strategic planning of flight schedules operated several months into the future, to real-time operations in which strategies must be developed and implemented immediately to recover scheduled operations from disruptions; and 2) they include multiple resources that must be coordinated, such as aircraft, crews, and passengers. While optimization approaches have been essential to the airline industry and effective in developing aircraft and crew schedules, historical models and approaches often fail to capture the complexity of airline operations. For example, approaches, often by necessity, involve a sequential, rather than an integrated process to develop schedules for aircraft and crews, and moreover, the process involves simplifying assumptions, including that future demands are known and deterministic, and that schedules are operated as planned. In more recent research on airline schedule optimization, advances have led to new schedule optimization models and approaches that more accurately reflect reality. As described in this presentation, the most notable contributions to these advances include: 1. Integrated Aircraft and Crew Schedule Optimization Approaches in which some of the aircraft and crew schedule decisions previously taken sequentially are integrated, moving closer to producing globally optimal schedules; 2. Dynamic Scheduling Approaches in which schedules are adjusted during the passenger booking period to reflect increased knowledge of booking patterns and to increase the schedule's associated total revenue; and 3. Robust Optimization Approaches in which the stochastic nature of airline operations is modeled and realized schedule performance is optimized.

Keywords: Airline aircraft and crew optimization, robust scheduling, dynamic scheduling

Joint work of: Barnhart, Cynthia; Jiang, Hai; Marla, Lavanya

Extended Abstract: <http://drops.dagstuhl.de/opus/volltexte/2009/2188>

Integrated Vehicle Routing and Crew Scheduling in Waste Management (Part II)

Jens Baudach (TU Dortmund, DE)

Planning Waste Management involves the two major resources collection-vehicles and crews. The overall goal of our project with two waste management companies is an integrative approach for planning the routes and the crews of the vehicles.

In the first phase of our three-phase approach we generate daily crew tasks which contain routes operated by a single crew at a particular day within a given disposal horizon considering various practical requirements. The goal is to minimize the number of crews/vehicles required for the entire disposal process. Given the minimal number of crews, in phase 2 we re-optimize the daily crew tasks to increase the robustness of the routes.

In the third phase we assign employees to the generated daily crew tasks for all working days over the year such that the constraints concerning crew scheduling are satisfied and the benefits for the employees and the company are maximal.

For all phases we present solution methods yielding first promising results for a real-world data set.

Keywords: Crew Scheduling, Waste Management, Integer Programming, Column Generation, Lagrangean Relaxation

Joint work of: Baudach, Jens; Chmielewski, Annette; Clausen, Uwe

Extended Abstract: <http://drops.dagstuhl.de/opus/volltexte/2009/2183>

Standard Software for Supply Chain Design and Optimization

Kati Brauer (4flow AG - Berlin, DE)

Immense levels of data and the complexity of current logistics networks have made software support indispensable. Recurring calculations in network design and transportation planning can be automated with the help of planning software. Furthermore sophisticated algorithms are available to improve planning performance and reduce planning efforts.

After a brief introduction of requirements in logistics planning, an overview of principal functionalities and applications of the standard software 4flow vista is presented. The paper focuses on manual and automated optimization techniques for network design and transportation planning and finishes with an outlook on future research in transportation planning which will be undertaken in the research project MultiTrans.

Keywords: Supply chain design, transportation planning, software, 4flow vista

Full Paper: <http://drops.dagstuhl.de/opus/volltexte/2009/2180>

Full Paper:
<http://www.4flow.com>

Optimization of Stochastic Discrete Event Simulation Models

Peter Buchholz (TU Dortmund, DE)

Many systems in logistics can be adequately modeled using stochastic discrete event simulation models.

Often these models are used to find a good or optimal configuration of the system. This implies that optimization algorithms have to be coupled with the models. Optimization of stochastic simulation models is a challenging research topic since the approaches should be efficient, reliable and should provide some guarantee to find at least in the limiting case with a runtime going to infinite the optimal solution with a probability converging to 1.

The talk gives an overview on the state of the art in simulation optimization. It shows that hybrid algorithms combining global and local optimization methods are currently the best class of optimization approaches in the area and it outlines the need for the development of software tools including available algorithms.

Keywords: Stochastic discrete event simulation, optimization, hybrid algorithms

Extended Abstract: <http://drops.dagstuhl.de/opus/volltexte/2009/2182>

Comparing Different Approaches on the Door Assignment Problem in LTL-Terminals

Annette Chmielewski (TU Dortmund, DE)

The work at hand yields two different ways to address the assignment of inbound and outbound doors in less-than-truckload terminals. The considered optimization methods stem from two different scientific fields, which makes the comparison of the techniques a very interesting topic. The first solution approach originates from the field of discrete mathematics. For this purpose, the logistical optimization task is modeled as a time-discrete multi-commodity flow problem with side constraints. Based on this model, a decomposition approach and a modified column generation approach are developed. The second considered optimization method is an evolutionary multi-objective optimization algorithm (EMOA). This approach is able to handle different optimization goals in parallel. Both algorithms are applied to ten test scenarios yielding different numbers of tours, doors, loading areas, and affected relations.

Keywords: Door Assignment Problem, Column Generation Approach, Multi-objective evolutionary algorithm approach

Joint work of: Naujoks, Boris; Chmielewski, Annette

Full Paper: <http://drops.dagstuhl.de/opus/volltexte/2009/2187>

Production Planning and Control with Discrete Lotsizing and a Rolling Horizon

Wilhelm Dangelmaier (Universität Paderborn, DE)

We consider a production system with discrete lotsizing as it is given in the automotive industry.

At any point of time only orders in the near future are known, but still the production has to be planned - leading to rolling horizons. Decisions that are made today should avoid bottlenecks in stock and capacity that will handicap future production. First we discuss approaches used in computing. Second we propose an approach that perform with good competitiveness compared to an optimal algorithm that knows the entire sequence of orders in advance.

Keywords: Online optimization, rolling horizon, lot size production, production planning and control

Joint work of: Dangelmeier, Wilhelm; Degener, Bastian

Full Paper: <http://drops.dagstuhl.de/opus/volltexte/2009/2186>

Humanitarian Supply Chain Management - An Overview

Ozlem Ergun (Georgia Institute of Technology, US)

Disasters recently received the attention of the Operations Research community due to the great potential of improving disaster related operations through the use of analytical tools, and the impact on people that this implies. In this introductory article, we describe the main characteristics of disaster supply chains, and we highlight the particular issues that are faced when managing these supply chains. We illustrate how Operations Research tools can be used to make better decisions, taking debris management operations as an example, and discuss potential general research directions in this area.

Keywords: Humanitarian logistics

Joint work of: Ergun, Ozlem; Karakus, Gonca; Keskinocak, Pinar; Swann, Julie; Villarreal, Monica

Extended Abstract: <http://drops.dagstuhl.de/opus/volltexte/2009/2181>

Single Car Routing in Rail Freight Service

Armin Fuegenschuh (Konrad-Zuse-Zentrum Berlin, DE)

Cars in rail freight services at Deutsche Bahn follow prescribed routes from their origin via intermediate shunting yards to their destination. The main goal in designing such routes is to reduce the number of trains and their travel distances. Various real-world capacity constraints make the problem difficult to formulate and also to solve. We present MILP and MINLP models for this problem based on multicommodity flows and arborescences. We compare these formulations using test- and real-world data.

Keywords: Mixed-Integer Programming, Branch-and-Cut, Logistics, Routing and Scheduling

Joint work of: Fuegenschuh, Armin; Homfeld, Henning; Schuelldorf, Hanno

Full Paper: <http://drops.dagstuhl.de/opus/volltexte/2009/2184>

Formulations, Bounds and Heuristic Methods for a Two-Echelon Adaptive Location-Distribution Problem

Bernard Gendron (Université de Montréal, CA)

We consider a two-echelon location-distribution problem arising from an actual application in fast delivery service. This problem belongs to the class of adaptive logistics problems, as the locations of the facilities (typically, parking spaces) are revised on a daily basis according to demand variations. We present and compare two formulations for this problem: an arc-based model and a path-based model. Since these formulations cannot be solved in reasonable time for large-scale instances, we introduce a heuristic method based on a variable neighborhood search approach.

Keywords: Two-echelon location problem, formulations, relaxations, variable neighborhood search

Joint work of: Gendron, Bernard; Khuong, Paul-Virak; Semet, Frédéric

Extended Abstract: <http://drops.dagstuhl.de/opus/volltexte/2009/2189>

Integrated Vehicle Routing and Crew Scheduling in Waste Management (Part I)

Ronny Hansmann (TU Braunschweig, DE)

Planning Waste Management involves the two major resources collection-vehicles and crews. The overall goal of our project with two waste management companies is an integrative approach for planning the routes and the crews of the vehicles.

In the first phase of our three-phase approach we generate daily crew tasks which contain routes operated by a single crew at a particular day within a given disposal horizon considering various practical requirements. The goal is to minimize the number of crews/vehicles required for the entire disposal process. Given the minimal number of crews, in phase 2 we re-optimize the daily crew tasks to increase the robustness of the routes.

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Keywords: Vehicle Routing, Crew Scheduling, Waste Management

Joint work of: Hansmann, Ronny; Zimmermann, Uwe

Extended Abstract: <http://drops.dagstuhl.de/opus/volltexte/2009/2185>

Network Models with Convex Cost Structure Like Bundle Methods

Christoph Helmberg (TU Chemnitz, DE)

For three rather diverse applications (truck scheduling for inter warehouse logistics, university-course timetabling, operational train timetabling) that contain integer multi-commodity flow as a major modeling element we present a computational comparison between a bundle and a full linear programming (LP) approach for solving the basic relaxations. In all three cases computing the optimal solutions with LP standard solvers is computationally very time consuming if not impractical due to high memory consumption while bundle methods produce solutions of sufficient but low accuracy in acceptable time.

The rounding heuristics generate comparable results for the exact and the approximate solutions, so this entails no loss in quality of the final solution. Furthermore, bundle methods facilitate the use of nonlinear convex cost functions. In practice this not only improves the quality of the relaxation but even seems to speed up convergence of the method.

Keywords: Lagrangian decomposition, large scale convex optimization, bundle methods, integer multi-commodity flow

Extended Abstract: <http://drops.dagstuhl.de/opus/volltexte/2009/2190>

Optimization of Mail Collection Networks

Christoph Hemsch (Deutsche Post DHL, Bonn, DE)

Some providers of postal or parcel services promise high levels of service to their customers, e.g., next day delivery, resulting in tight lead times. To meet these high service levels, complex logistics networks need to be planned and operated. Such networks are typically divided into transportation of letters or parcels from customer locations to a local sorting terminal (collection), inter-terminal transportation, and transportation from a terminal to customer locations (delivery). Within postal logistics networks the interaction of processing at and transportation between different kinds of facilities plays a vital role. Normally, collection and initial sorting, as well as inter-terminal transportation and final sorting need to be finished before certain cut-off times. Thus, guaranteeing the subsequent transportation to start on time.

The talk presents various optimization problems within the part of a postal logistics network where collection takes place. Then, two of those problems are presented in more detail. First, the allocation of pickup locations to sorting terminals and, second, the optimization of collection tours. Both problems not only consider service time windows at customer locations and at terminals but also complex sorting capacities at the sorting terminals. For both problems appropriate mathematical models and solution methods will be discussed. Also generic and practical applications are presented.

Keywords: Postal logistics, allocation, VRPTW

Extended Abstract: <http://drops.dagstuhl.de/opus/volltexte/2009/2162>

Reoptimization Algorithms for Passenger Elevator Control

Benjamin Hiller (Konrad-Zuse-Zentrum Berlin, DE)

The task of an elevator control is to schedule the elevators of a group such that small average and maximal waiting and travel times for the passengers are obtained. We present a novel exact reoptimization algorithm for this problem. A reoptimization algorithm computes a new optimal schedule for the elevator group each time a new passenger arrives. Our algorithm uses column generation techniques and is, to the best of our knowledge, the first exact reoptimization algorithm for a group of elevators. We use our algorithm to compare the potential performance that can be achieved for conventional (ie up/down buttons) and two variants of destination call systems, where a passenger enters his destination floor when calling an elevator. This research is part of an ongoing project with our industry partner Kollmorgen Steuerungstechnik.

Keywords: Elevator control, reoptimization, online optimization

Joint work of: Hiller, Benjamin; Klug, Torsten; Tuchscherer, Andreas

Extended Abstract: <http://drops.dagstuhl.de/opus/volltexte/2009/2179>

The New Dutch Timetable: The OR Revolution

Dennis Huisman (Erasmus University - Rotterdam, NL)

On April 14, 2008, INFORMS (The Institute for Operations Research and Management Sciences) announced Netherlands Railways to be the winner of the 2008 Franz Edelman Award. In this extended abstract, we give a short summary of both the paper and the presentation of the winning team.

Keywords: Timetable

Full Paper: <http://drops.dagstuhl.de/opus/volltexte/2009/2169>

New Models and Methods for Arc Routing

Stefan Irnich (RWTH Aachen, DE)

The talk presents two non-standard extensions for single-vehicle arc-routing problems a.k.a. postman problems: First, street segments that require a service on both sides of the street can be covered either by two separate services or by a single zigzag service.

Instead of deciding the type of service beforehand, we propose to take into account the zigzagging option when designing a tour. We present MIP models for the extension of Undirected Chinese and Rural Postman Problem (UCPP, URPP). We show that these models can be solved (reasonable well) using a cutting-plane or branch-and-cut algorithm. Second, capacitated postman problems occur as subproblems in column-generation and Lagrangian-relaxation approaches of the capacitated arc-routing problem. In order to model these and similar subproblems or submodels, we present the Profitable Capacitated Rural Postman Problem (PCRPP): In the PCRPP, edges that are serviced give a profit, but deadheading through edges generates costs. Both service and deadheading consume time. The task is to find a tour that maximizes the difference of profits and costs, while the overall duration of the tour must not exceed a given bound. The solution approach for this problem is again based on branch-and-cut.

Keywords: Postman problems, arc routing, branch-and-cut

Extended Abstract: <http://drops.dagstuhl.de/opus/volltexte/2009/2163>

Online Traveling Salesman Problems with Flexibility

Patrick Jaillet (MIT - Cambridge, US)

The Traveling Salesman Problem (TSP) is a well-known combinatorial optimization problem. We are concerned here with online versions of a generalization of the TSP on metric spaces where the server doesn't have to accept all requests. Associated with each request (to visit a point in the metric space) is a penalty (incurred if the request is rejected). Requests are revealed over time to a server, initially at a given origin, who must decide which requests to serve in order to minimize the time to serve all accepted requests plus the sum of the penalties associated with the rejected requests.

In a first online version of this problem (basic version), we assume that the server's decision to accept or reject a request can be made any time after its release date. In a second online version of this problem (real-time version), we assume that the server's decision to accept or reject a request must be made exactly at its release date.

After reviewing prior results on the online TSP, we first provide an optimal 2-competitive online algorithm for the basic version of the problem in a general metric space, improving prior results from the literature. We then consider the real-time version of the problem and show that there can't be any finite c -competitive online algorithm in a general metric space.

Keywords: Online TSP, service flexibility, rejection options

Joint work of: Jaillet, Patrick; Lu, Xin

Extended Abstract: <http://drops.dagstuhl.de/opus/volltexte/2009/2172>

Aspects and Views on Mathematical Optimization in Logistics in the Chemical Process Industry

Josef Kallrath (BASF SE - Ludwigshafen, DE)

In large chemical companies, traffic logistics and supply chain logistics contain many decision problems which are suitable to be solved by mathematical optimization. The objectives are to exploit resources (traffic infrastructure such as roads and rail lines, production equipment) in a cost optimal way and to maximize profit.

We present two cases: optimal sequences of rail cars in trains visiting various plants in a large company complex, and production and distribution planning. Finally, we discuss the importance of data structure and the consequences of differences between the "booking world" view of systems such as SAP and the "physical world" mapped into mathematical optimization models.

Keywords: Logistics, traffic, supply chain, role of data, planning systems, data interfacing to SAP

Full Paper: <http://drops.dagstuhl.de/opus/volltexte/2009/2161>

A Network Design Problem

Anton J. Kleywegt (Georgia Institute of Technology, US)

We consider the problem of designing a distribution network to facilitate the repeated movement of shipments from many origins to many destinations. A sufficient number of the origin-destination shipments require less than the capacity of a vehicle, so that consolidation of shipments is economical. We consider the case in which consolidation takes place at terminals, and we assume each shipment moves through exactly one terminal on its way from its origin to its destination. Then, a major design decision is to determine the best number of terminals. We develop a continuous approximation method to estimate transportation costs as a function of the number of terminals. We use the continuous approximation method to choose the number of terminals that minimizes the sum of terminal cost and transportation cost.

Numerical results indicate that the design resulting from the continuous approximation method facilitates operations with lower cost than those resulting from a widely used integer programming based design.

Keywords: Network design, continuous approximation

Joint work of: Kleywegt, Anton J.; Lee Jinpyo; Ward, Amy R.

Full Paper: <http://drops.dagstuhl.de/opus/volltexte/2009/2176>

Sequencing and Scheduling in Coil Coating with Shuttles

Felix Koenig (TU Berlin, DE)

Applying combinatorial optimization in real life yields cost savings delighting the industry. Beyond that, at the core of some applications also lies a pretty (sub)problem rejoicing the mathematician. In our application coils of sheet metal are coated with k layers out of hundreds of colors. Coils are stapled together to run through k coaters, and non-productive time occurs e.g. when the color in a coater needs to be changed. Some coaters have two parallel tanks, enabling either parallel colors or cleaning of one tank during production. We present our sequencing and scheduling scheme in use at the plant today, lower bounds proving solution quality, and problems in the edge-wise union of interval graphs as a pretty mathematical subproblem.

Keywords: Sequencing, scheduling, coil coating, mutli-interval graphs, heuristics, branch and price

Joint work of: Höhn, Wiebke; König, Felix G.; Lübbecke, Marco E.; Möhring, Rolf H.

Full Paper: <http://drops.dagstuhl.de/opus/volltexte/2009/2165>

A Fast Tool for UMTS Site Roll-Out

Ulrich Lauther (Siemens AG - München, DE)

The site roll-out problem comes up in the early green-field planning phase of UMTS mobile networks, where the number and location of sites (base stations) to be deployed have to be determined.

This is a difficult problem, as the traffic a base station can serve, depends in a complicated way on the propagation environment (urban, sea, forest, ...) and the expected traffic density in its vicinity: higher traffic densities reduce the range that a base station can cover, but increase its effective capacity.

We present a simple model using at input data polygonal shapes describing (after scaling) the area that can be served by a base station, a pixel-wise estimation of traffic data and also pixel-wise clutter data describing propagation conditions. We show how from traffic density and clutter type in the vicinity of a site candidate the maximum allowable scaling of the antenna shape is derived. We then discuss a simple greedy heuristic for covering the planning region with base stations, various improvement heuristics and programming tricks to speed up the process.

The tool is quite fast and gives results good enough for an initial bidding phase and that are usable as a starting point for more sophisticated planning steps which require more input data (e.g., field strength predictions found by ray tracing) and much more running time.

Joint work of: Lauther, Ulrich; Winter, Thomas; Tuerke, Ulrich

The Transport PDE and Mixed-Integer Linear Programming

Alexander Martin (TU Darmstadt, DE)

Discrete, nonlinear and PDE constrained optimization are mostly considered as different fields of mathematical research. Nevertheless many real-life problems are most naturally modeled as PDE constrained mixed integer nonlinear programs.

For example, nonlinear network flow problems where the flow dynamics are governed by a transport equation are of this type. We present four different applications together with the derivation of the associated transport equations and we show how to model these problems in terms of mixed integer linear constraints.

Keywords: Transport Equation, Partial Differential Equation, Mixed-Integer Linear Programming, Modeling, Nonlinear Constraints

Joint work of: Fügenschuh, Armin; Geißler, Björn; Martin, Alexander; Morsi, Antonio

Full Paper: <http://drops.dagstuhl.de/opus/volltexte/2009/2167>

Using Branch-and-Price to Find High Quality Solutions Quickly

George Nemhauser (Georgia Institute of Technology, US)

We develop an exact solution approach for integer programs that produces high-quality solutions quickly by solving well-chosen restrictions of the problem. Column generation is used both for generating these problem restrictions and for producing bounds on the value of an optimal solution to the problem. Obtaining primal solutions by solving problem restrictions also provides an easy way to search for improved solutions in the neighborhood of the current best solution. The overall approach is parallelized and computational experiments demonstrate its efficiency. An application to inventory routing is presented.

Keywords: Column generation, branch-and-price, mixed-integer programming, inventory routing

Joint work of: Nemhauser, George; Hewitt, Mike; Savelsbergh, Martin

Extended Abstract: <http://drops.dagstuhl.de/opus/volltexte/2009/2168>

Line Planning and Connectivity

Marika Neumann (Konrad-Zuse-Zentrum Berlin, DE)

The line planning problem in public transport deals with the construction of a system of lines that is both attractive for the passengers and of low costs for the operator. It can be modeled as a multi-commodity-flow problem in which line and passenger paths are constructed.

In general, the computed line system should be connected, i.e., for each two stations there have to be a path that is covered by the lines.

This problem is a generalization of the well-known Steiner tree problem; we call it the Steiner connectivity Problem.

We discuss complexity of this problem, generalize the so-called Steiner partition inequalities and give a transformation to the directed Steiner tree problem. We show that directed models provide tight formulations for the Steiner connectivity problem, similar as for the Steiner tree problem.

Joint work of: Neumann, Marika; Borndörfer, Ralf; Pfetsch, Marc

Extended Abstract: <http://drops.dagstuhl.de/opus/volltexte/2009/2166>

Managing Capacity by Drift Control

Melda Ormeci Matoglu (Ozyegin University - Istanbul, TR)

We model the problem of managing capacity in a build-to-order environment as a Brownian drift control problem and seek a policy that minimizes the long-term average cost. We assume the controller can, at some cost, shift the processing rate among a finite set of alternatives by, for example, adding or removing staff, increasing or reducing the number of shifts or opening or closing production lines. The controller incurs a cost for capacity per unit time and a delay cost that reflects the opportunity cost of revenue waiting to be recognized or the customer service impacts of delaying delivery of orders. Furthermore he incurs a cost per unit to reject orders or idle resources as necessary to keep the workload of waiting orders within a prescribed range. We introduce a practical restriction on this problem, called the \mathcal{S} -restricted Brownian control problem, and show how to model it via a structured linear program. We demonstrate that an optimal solution to the \mathcal{S} -restricted problem can be found among a special class of policies called deterministic non-overlapping control band policies. These results exploit apparently new relationships between complementary dual solutions and relative value functions that allow us to obtain a lower bound on the average cost of any non-anticipating policy for the problem even without the \mathcal{S} restriction. Under mild assumptions on the cost parameters, we show that our linear programming approach is asymptotically optimal for the unrestricted Brownian control problem in the sense that by appropriately selecting the \mathcal{S} -restricted problem, we can ensure its solution is within an arbitrary finite tolerance of a lower bound on the average cost of any non-anticipating policy for the unrestricted Brownian control problem.

Keywords: Capacity Management, Brownian Motion, LP, Relative Value Function, Duality

Joint work of: Ormeci Matoglu, Melda; Vande Vate, John

Full Paper: <http://drops.dagstuhl.de/opus/volltexte/2009/2159>

Branch-and-Price Solving in G12

Jakob Puchinger (AIT - Austrian Institute of Technology, AT)

The G12 project is developing a software environment for stating and solving combinatorial problems by mapping a high-level model of the problem to an efficient combination of solving methods. Model annotations are used to control this process.

In this paper we explain the mapping to branch-and-price solving. G12 supports the selection of specialised subproblem solvers, the aggregation of identical subproblems, automatic disaggregation when required by search, and the use of specialised branching rules. We demonstrate the benefits of the G12 framework on three examples: a trucking problem, cutting stock, and two-dimensional bin packing.

Keywords: Combinatorial optimization, branch-and-price, software

Joint work of: Puchinger, Jakob; Stuckey, Peter; Wallace, Mark; Brand, Sebastian

Extended Abstract: <http://drops.dagstuhl.de/opus/volltexte/2009/2164>

The Combinatorics of (S,M,L,XL) or the Best Fitting Delivery of T-shirts

Joerg Rambau (Universität Bayreuth, DE)

A fashion discounter supplies its branches with apparel in various sizes. Apparel is ordered in pre-packs three months in advance from overseas: replenishment impossible. Thus, the supply in each size and branch must be consistent with the demand right away. We present new ILP-models for the resulting lot-type design problem: For each branch, find lot types and delivery volumes so that the demand is met best. Our vision is an integrated price-and-size optimization model that takes the mark-down process into account when placing the orders. The results are applied by a german fashion discounter with over 1000 branches.

Keywords: Supply chain management, fashion retailer, integer linear programming, demand forecasting

Joint work of: Gaul, Constantin; Kurz, Sascha; Rambau, Jörg

Full Paper: <http://drops.dagstuhl.de/opus/volltexte/2009/2171>

Full Paper:

<http://www.informaworld.com/10.1080/10556780902965163>

See also: Extended abstract of: Gaul, C., Kurz, S., Rambau, J.: On the lot-type design problem. Optimization Methods and Software (2009)

Grammar-Based Integer Programming Models for Multi-Activity Shift Scheduling

Louis-Martin Rousseau (Ecole Polytechnique - Montreal, CA)

We present a new implicit formulation for shift scheduling problems, using context-free grammars to model regulation in the composition of shifts. From the grammar, we generate an integer programming (IP) model allowing the same set of shifts as Dantzig's set covering model. When solved by a state-of-the-art IP solver on problems allowing a small number of shifts, our model, the set covering formulation and a typical implicit model from the literature yield comparable solving times. Moreover, on instances where many shifts are allowed, our model is superior and can encode a wider variety of constraints. Among others, multi-activity cases, which cannot be modeled by existing implicit formulations, can easily be captured with grammars.

Keywords: Shift Scheduling, Implicit models, Integer Programming, Context-free grammars

Joint work of: Cote, Marie-Claude; Gendron, Bernard; Rousseau, Louis-Martin

Extended Abstract: <http://drops.dagstuhl.de/opus/volltexte/2009/2177>

Optimization at Deutsche Bahn: Aspects and Examples

Hanno Schuelldorf (DB Mobility Logistics AG - Frankfurt am Main, DE)

For large transportation companies like Deutsche Bahn, process optimization has always been an important task to reduce production costs and obtain a better position in competition. Applying methods of mathematical optimization in practice often is rather difficult though, which may lead to some unique constraints that could make the optimization process rather hard. This contribution shall discuss some practical issues for mathematical optimization at Deutsche Bahn and will give some examples.

Keywords: Deutsche Bahn, simulation, optimization, practical aspects

Full Paper: <http://drops.dagstuhl.de/opus/volltexte/2009/2174>

Increasing Stability of Crew Schedules

Leena Suhl (Universität Paderborn, DE)

In airline and bus traffic disruptions occur frequently and cannot be totally avoided. They may lead to infeasible vehicle and crew schedules during the day of operations, due to absence of resources or violation of crew rules. The short-term recovery actions usually imply additional costs meaning that the total operational costs of a crew schedule can be significantly higher than the original planned costs. It is generally desirable to construct the schedule already in the planning phase in such a way that not just the planned costs, but the total operational costs are minimized. The goal is thus to construct schedules which remain feasible or can be recovered without high costs in cases of disturbances. This approach is generally called robust scheduling.

We discuss a two-stage stochastic optimization model with recourse for the integrated crew pairing and aircraft routing problem. A simplified version can be solved iteratively with increasing penalty for aircraft changes of crew. We use a column generation approach and evaluate the robustness of each pairing during pricing. Additionally to the delay within an aircraft rotation the propagated delay between aircraft due to crew changes is evaluated. Aircraft changes can be classified based on historical data.

Keywords: Robust planning, crew scheduling, airlines

Joint work of: Suhl, Leena; Dück, Viktor; Kliewer, Natalia

Extended Abstract: <http://drops.dagstuhl.de/opus/volltexte/2009/2178>

Sharing Supermodular Costs

Nelson A. Uhan (Purdue University, US)

We apply ideas from cooperative game theory to study situations in which a set of agents face supermodular costs. These situations appear in a variety of scheduling contexts, as well as in some settings related to facility location and network design. Intuitively, cooperation amongst rational agents who face supermodular costs is unlikely. However, in circumstances where the failure to cooperate may lead to negative externalities, one might be interested in methods of encouraging cooperation. The least core value of a cooperative game is the minimum penalty we need to charge a coalition for acting independently that encourages cooperation by ensuring the existence of an efficient and stable cost allocation. The set of all such cost allocations is called the least core. In this work, we study the computational complexity and approximability of computing the least core value of supermodular cost cooperative games. We show that computing the least core value of supermodular cost cooperative games is strongly NP-hard, and build a framework to approximate the least core value of these games using oracles

that approximately determine maximally violated constraints. This framework yields a $(3 + \epsilon)$ -approximation algorithm for computing the least core value of supermodular cost cooperative games. As a by-product, we show how to compute accompanying approximate least core cost allocations for these games. We also apply our approximation framework to obtain better results for two particular classes of supermodular cost cooperative games that arise from scheduling and matroid optimization.

Keywords: Cooperative games, approximation algorithms, algorithmic game theory

Joint work of: Schulz, Andreas S.; Uhan, Nelson A.

Extended Abstract: <http://drops.dagstuhl.de/opus/volltexte/2009/2170>

A Robust PTAS for the Parallel Machine Covering Problem

Jose Verschae (TU Berlin, DE)

In general, combinatorial optimization problems are unstable: slight changes on the instance of a problem can render huge changes in the optimal solution. Thus, a natural question arises: Can we achieve stability if we only maintain approximate solutions?. In this talk I will first formalize these ideas, and then show some results on the parallel machine covering problem. In particular I will derive a robust PTAS, i.e., I will show how to construct a solution that is not only $(1 - \epsilon)$ -approximate, but is also stable. That is, if the instance is changed by adding or removing a job, then we can construct a new near-optimal solution by only slightly modifying the previous one.

Keywords: Stability, approximation schemes, online algorithms

Joint work of: Skutella, Martin; Verschae, Jose

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Traffic Information and Dynamic Vehicle Routing in Forwarding Agencies

Sascha Wohlgemuth (TU Dortmund, DE)

Freight transportation is essential for most economies. The main focus is on forwarding agencies handling less-than-truckload freight. In general, direct transportation from origin to destination would be too expensive.

Therefore, the main idea is to consolidate enough small shipments to efficiently conduct transportation for the majority of the distance. In preparation of this transport it is necessary to pick up commodities from different customer locations in the origin region. At the transshipment point consignments with the same destination region are grouped on one truck heading for this region. Upon arrival they are transshipped again on smaller trucks and distributed to the customers.

Nearly every transshipment point collects as well as rolls out goods. Thus, typical forwarding agencies perform pickups as well as deliveries conjoined on the same vehicle. They have to cope with hundreds of pickups and deliveries each day and a few tens of vehicles are necessary to service the customers in the local region. The performance is mainly influenced by two dynamic factors: First, due to developments in information and communication technology, the agencies receive pickup orders increased shortly before the actual pickup. Second, unexpected traffic situations are endangering the scheduled pickups, though traffic information is increasingly available. Surprisingly this information is hardly used in the forwarding industry, even though vehicle locations are available in real-time via global positioning systems. The consequence is that these companies are fighting lateness of shipments and poor utilization of vehicles. Therefore, the objective is to develop an intelligent planning system based on mathematical optimization heuristics to assist forwarding agencies in routing vehicles efficiently.

Keywords: Dynamic vehicle routing, pickup and delivery problem, forwarding agency, less-than-truckload freight, varying travel times, clustering, tabu search

Joint work of: Wohlgemuth, Sascha; Clausen; Uwe

Full Paper: <http://drops.dagstuhl.de/opus/volltexte/2009/2173>